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Status Report

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Soft X-ray Optics by Pulsed Laser Deposition

Félix E. Fernández
University of Puerto Rico
Department of Physics
Mayaguez, P.R. 00681

Tel.: (809) 265 - 3844
FAX : (809) 832 - 4680
e-mail: f_fernandez@rumac.upr.clu.edu

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An excimer laser for improvement of the Pulsed Laser Deposition system was ordered on June 30. Careful consideration was given to characteristics of approximately similar lasers from several manufacturers (Lambda Physik, Lumonics, Sopra, MPB). A Lambda Physik model Compex 110 was selected as the one best meeting the requirements in terms of power, control, reliability, cost, and other factors. There was a delay of more than two months with respect to the date of NASA approval of partial funding for this equipment. This was due to sluggish procedures for official approval of the corresponding institutional funds (53 % of the total), which had been assured verbally. Unfortunately, the company selected has a backlog of orders, which means that delivery is scheduled for late October.

As reported previously, characterization results of PLD-grown Mo/Si multilayers proved them unsatisfactory. This was due mainly to the marked deviation from target normal of the Mo plume after relatively few pulses. In order to attempt different material pairs a reflector for 45.8 Å (i.e., near the carbon K edge) at normal incidence was designed. Carbon and cobalt are a good pair of materials for this range. The design calls for 9.5 Å cobalt and 13.5 Å for the carbon spacers, with about 200 bilayers for saturation.

Film growth was performed from pyrolythic graphite and Co sputtering targets with 355 nm laser pulses. PLD growth of carbon does not present particular difficulties. For Co, as for other highly reflective metals, yield is low. It was observed that plume deviation from normal occurs, although it is not as marked as in the case of Mo. Calibration lines for Co and C were deposited for a target-substrate distance of 4 cm, and their thicknesses measured with a Tolansky interferometer. Estimated average growth rates at a laser fluence of a few J/cm^2, the minimum required for evaporation of Co, were 0.032 Å/pulse and 0.072 for Co and C, respectively. In principle, these rates should allow adequate thickness control, but this is of course spoiled by poor lateral thickness control. The similar yield of Co and C is advantageous for PLD growth via a source for which output power cannot be directly controlled "on the fly", such as our current Nd:YAG laser. This did represent a problem for Mo/Si multilayers, because the Si yield is much higher than that of Mo. Both Co and C films grown in preliminary runs are of good quality, with very smooth surfaces, as observed with optical microscope and SEM. In the case of Co there is some particulate due mainly to ejection of micron-sized liquid droplets.

A number of samples of Co/C multilayers were grown on Si wafers for XRD and Auger depth profiling analysis. While low-angle XRD scans (with a standard powder diffractometer) do show maxima near calculated Bragg peaks, these are poorly developed. This is not surprising because of (1) the relative importance of roughness for such thin layers, (2) the probable lack of in-plane layer uniformity inherent in the PLD process, and (3) the unsuitability of the diffractometer available for the task. On the other hand, the multilayer period preliminarily estimated from the XRD results is within a few Amstrongs of the design value of 23 Å.

Auger profiling of the samples shows very good layering, as evidenced in the accompanying graph. As the electron beam probes a relatively small area of the sample, lateral uniformity is not an issue in this case. It is noted that, particularly for such thin layers, the ion beam is expected to mix the materials and destroy the layering. This appears to be the case after the first few layers. More detailed Auger analysis of these, as well as of the previously fabricated Mo/Si samples is underway.

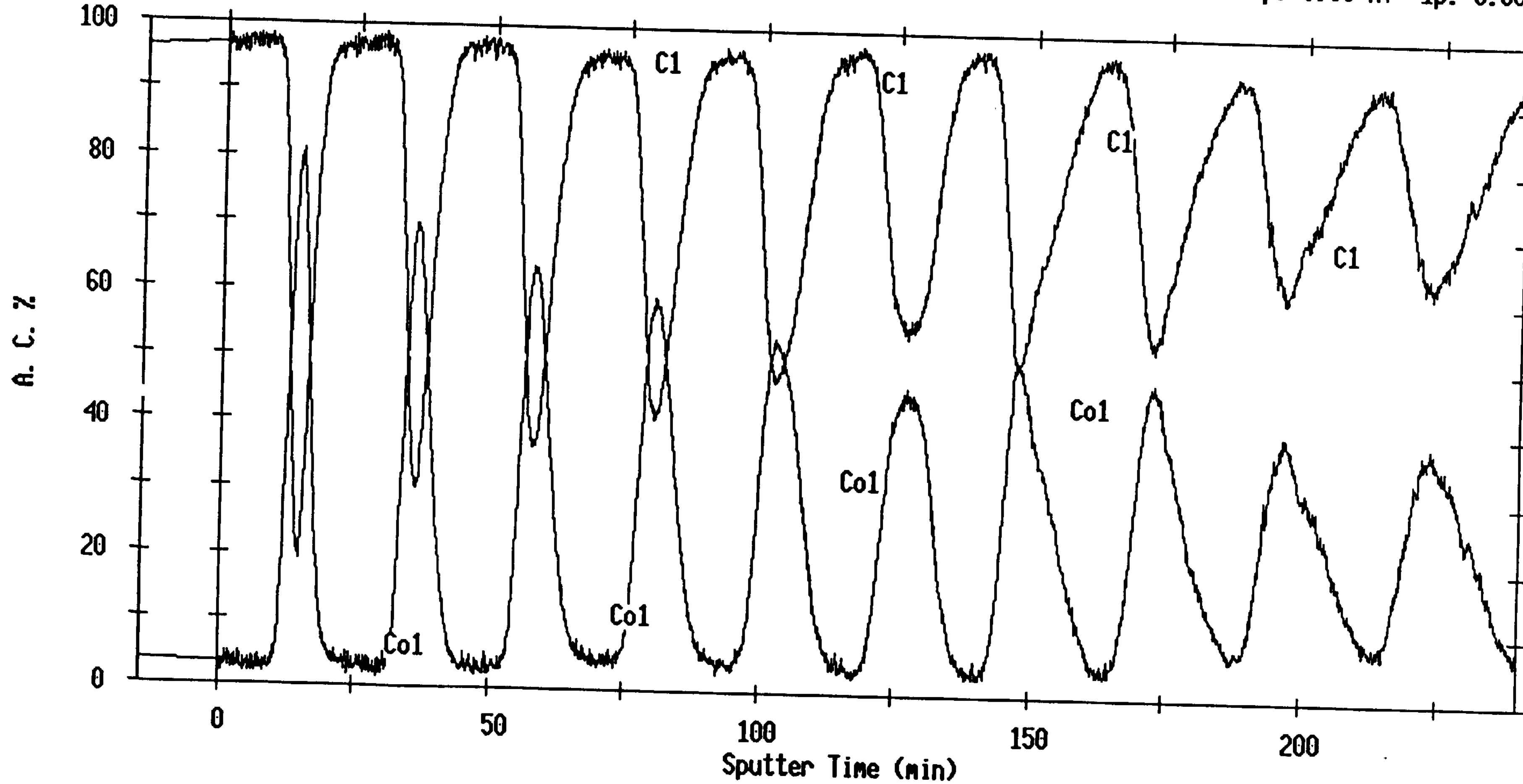
An apparatus for beam scanning during deposition is near completion. This will allow scanning in an elliptical path by very simple means. Elliptical paths are required in order to produc a circular source pattern on a flat target inclined v ith respect to

AES Depth Profile V/f Alternating 18 May 95 Species: Co1 Region: 2 Area: 1 Sputter Time: 240.00 min

File: RUM6 sample 298 C/Co

Scale Factor: 0.050 kc/s Offset: 0.000 kc/s

Ep: 5.00 kV Ip: 0.0000 uA



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the incoming beam. The mechanism design is original, and an invention disclosure is being prepared.

One graduate student has participated in part of this research during the time covered by this report. He is finishing writing his M.S. thesis and expects to have the oral defense at the beginning of this semester. During this period, a paper previously accepted for publication by Journal of Vacuum Science and Technology - A appeared in the March/April issue.